TPS562200EVM-601 2-A, SWIFT™ Regulator Evaluation

This user's guide contains information for the TPS562200 as well as support documentation for the TPS562200EVM-601 evaluation module. Included are the performance specifications, schematic, and the bill of materials of the TPS562200EVM-601.

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1 Introduction

The TPS562200 is a single, adaptive on-time, D-CAP2™ mode, synchronous buck converter requiring a very low external component count. The D-CAP2 control circuit is optimized for low-ESR output capacitors such as POSCAP, SP-CAP, or ceramic types and features fast transient response with no external compensation. The switching frequency is internally set at a nominal 650 kHz. The high-side and low-side switching MOSFETs are incorporated inside the TPS562200 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS562200 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS562200 dc/dc synchronous converter is designed to provide up to a 2-A output from an input voltage source of 4.5 V to 17 V. The output voltage range is from 0.8 V to 6.5 V. Rated input voltage and output current ranges for the evaluation module are given in Table 1.

The TPS562200EVM-601 evaluation module (EVM) is a single, synchronous buck converter providing 1.05 V at 2 A from 4.5-V to 17-V input. This user's guide describes the TPS562200EVM-601 performance.

Table 1. Input Voltage and Output Current Summary

EVM	Input Voltage Range	Output Current Range
TPS562200EVM-601	V_{IN} = 4.5 V to 17 V	0 A to 2 A

2 Performance Specification Summary

A summary of the TPS562200EVM-601 performance specifications is provided in Table 2. Specifications are given for an input voltage of V_{IN} = 12 V and an output voltage of 1.05 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2. TPS562200EVM-601Performance Specifications Summary

Specifications		Test Conditions	Min	Typ	Max	Unit
Input voltage range (V_{IN})			4.5	12	17	V
CH1	Output voltage			1.05		V
	Operating frequency	V_{IN} = 12 V, I_O = 2 A		650		kHz
	Output current range		0		2	A
	Over current limit	V_{IN} = 12 V, L_O = 2.2 µH				A
	Output ripple voltage	V_{IN} = 12 V, I_O = 2 A		20		mV_{PP}

3 Modifications

These evaluation modules are designed to provide access to the features of the TPS562200. Some modifications can be made to this module.

3.1 Output Voltage Setpoint

To change the output voltage of the EVMs, it is necessary to change the value of resistor R5. Changing the value of R5 can change the output voltage above 0.765 V. The value of R5 for a specific output voltage can be calculated using Equation 1.

$$R5 = \frac{R6 \times (V_{OUT} - 0.765\ V)}{0.765\ V} \quad (1)$$

Table 3 lists the R5 values for some common output voltages. For higher output voltages of 1.8 V or above, a feedforward capacitor (C9) may be used to improve phase margin. Pads for this component (C9) are provided on the printed-circuit board. Note that the values given in Table 3 are standard values and not the exact value calculated using Table 3.

Table 3. Output Voltages

Output Voltage (V)	R5 (kΩ)	R6 (kΩ)	C9 (pF)	L1 (µH)			C6 + C7 +C8 (µF)
				Min	Typ	Max	
1.0	15.4	49.9		1.5	2.2	4.7	20 - 68
1.05	18.7	49.9		1.5	2.2	4.7	20 - 68
1.2	28.7	49.9		1.5	2.2	4.7	20 - 68
1.5	47.5	49.9		1.5	2.2	4.7	20 - 68
1.8	68.1	49.9	optional, 10 pF max	1.5	2.2	4.7	20 - 68
2.5	113	49.9	optional, 10 pF max	2.2	3.3	4.7	20 - 68
3.3	165	49.9	optional, 10 pF max	2.2	3.3	4.7	20 - 68
5.0	274	49.9	optional, 10 pF max	3.3	4.7	4.7	20 - 68
6.5	374	49.9	optional, 10 pF max	3.3	4.7	4.7	20 - 68

4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS562200EVM-601. The section also includes test results typical for the evaluation modules and efficiency, output load regulation, output line regulation, load transient response, output voltage ripple, input voltage ripple, start-up, and switching frequency.

4.1 Input/Output Connections

The TPS562200EVM-601 is provided with input/output connectors and test points as shown in Table 4. A power supply capable of supplying 2 A must be connected to J1 through a pair of 20-AWG wires. The load must be connected to J2 through a pair of 20-AWG wires. The maximum load current capability is 2 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP1 provides a place to monitor the V_{IN} input voltages with TP2 providing a convenient ground reference. TP7 is used to monitor the output voltage with TP8 as the ground reference.

Table 4. Connection and Test Points

Reference Designator	Function
J1	V_{IN} (see Table 1 for V_{IN} range)
J2	V_{OUT}, 1.05 V at 2-A maximum
JP1	EN control. Shunt EN to GND to disable, shunt EN to V_{IN} to enable.
TP1	V_{IN} positive monitor point
TP2	GND monitor test point
TP3	EN test point
TP4	Switch node test point
TP5	Test point for loop response measurements
TP6	V_{OUT} positive monitor point
TP7	GND monitor test point

4.2 Start-Up Procedure

1. Ensure that the jumper at JP1 (Enable control) pins 1 and 2 are covered to shunt EN to GND, disabling the output.
2. Apply appropriate V_{IN} voltage to VI (J1-2) and GND (J1-1).
3. Move the jumper at JP1 (Enable control) from pins 1 and 2 (EN and GND), to pins 2 and 3 (EN and V_{IN}) enabling the output.

4.3 Efficiency

Figure 1 shows the efficiency for the TPS562200EVM-601 at an ambient temperature of 25°C.

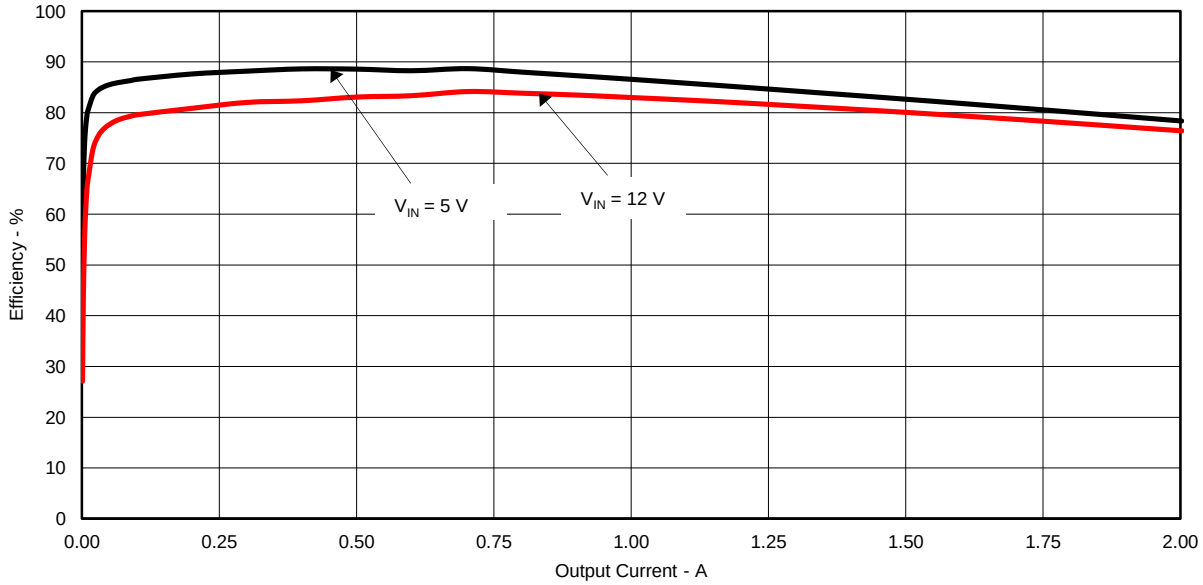

Figure 1. TPS562200EVM-601 Efficiency

Figure 2 shows the efficiency at light loads for the TPS562200EVM-601 at an ambient temperature of 25°C.

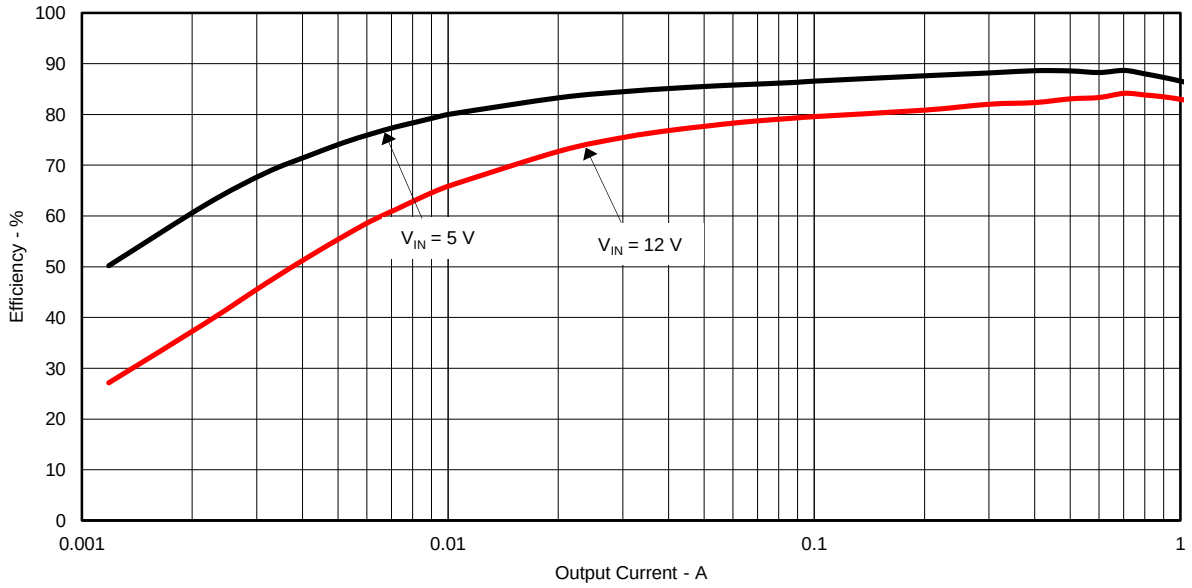

Figure 2. TPS562200EVM-601 Light Load Efficiency

4.4 Load Regulation

The load regulation for the TPS562200EVM-601 is shown in Figure 3.

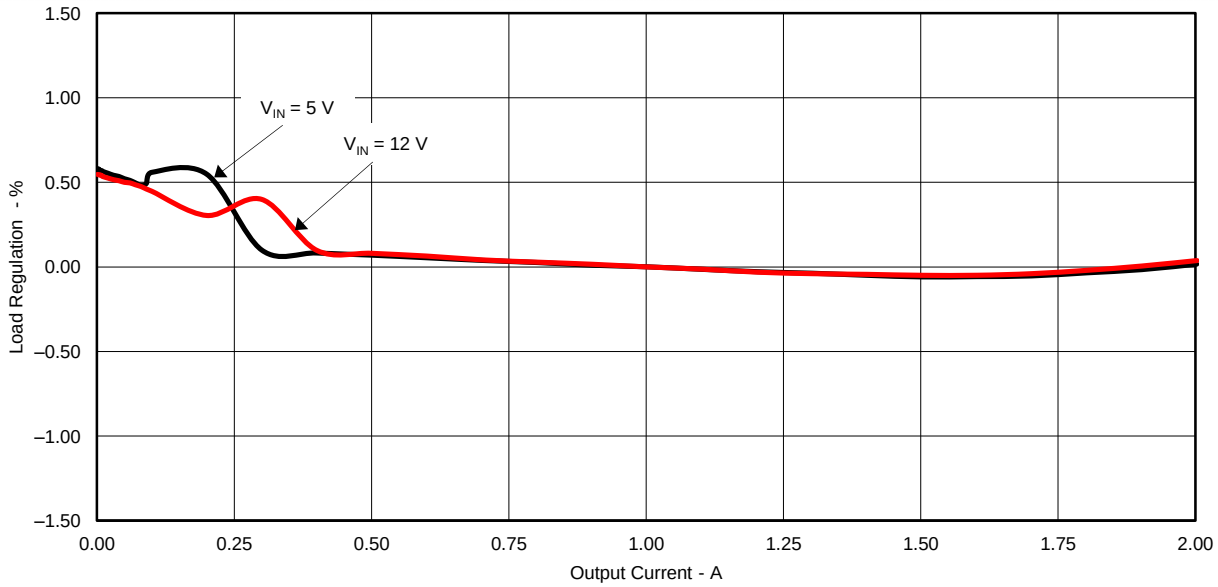

Figure 3. TPS562200EVM-601 Load Regulation

4.5 Line Regulation

The line regulation for the TPS562200EVM-601 is shown in Figure 4.

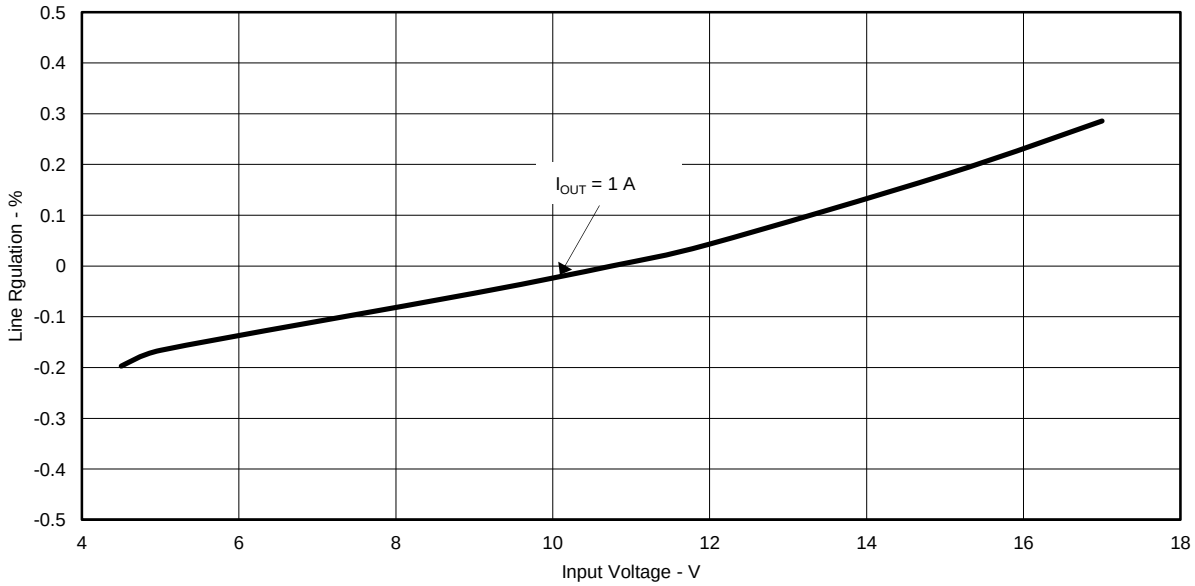

Figure 4. TPS562200EVM-601 Line Regulation

4.6 Load Transient Response

The TPS562200EVM-601 response to load transient is shown in Figure 5. The current steps and slew rates are indicated in the figures. Total peak-to-peak voltage variation is as shown.

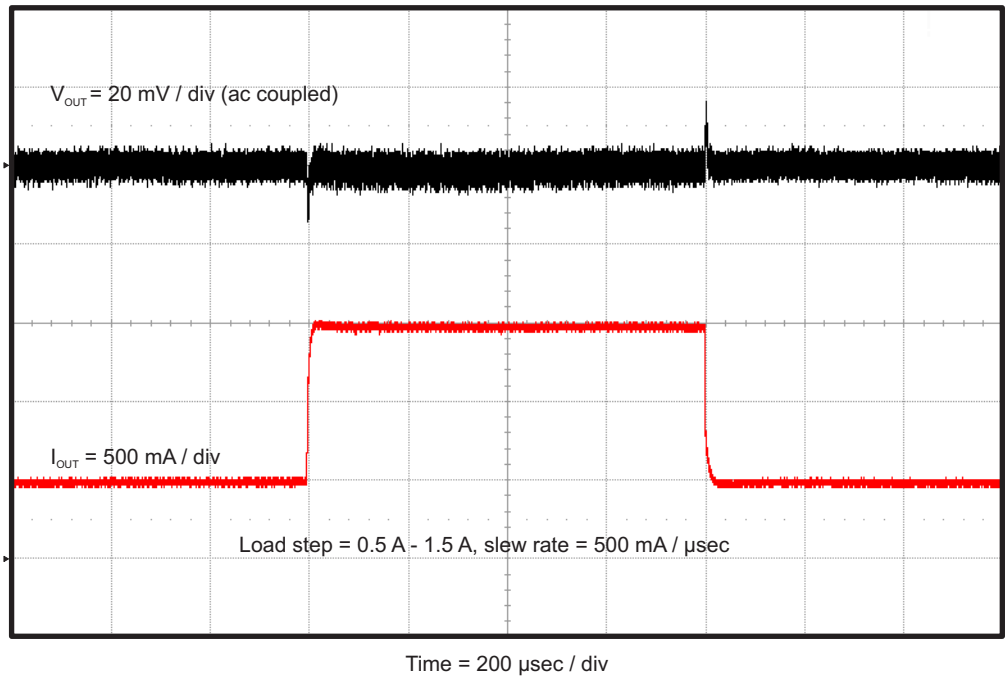

Figure 5. TPS562200EVM-601 Load Transient Response, 25% to 75% Load Step

4.7 Output Voltage Ripple

The TPS562200EVM-601 output voltage ripple is shown in Figure 6, Figure 7, and Figure 8. The output currents are as indicated.

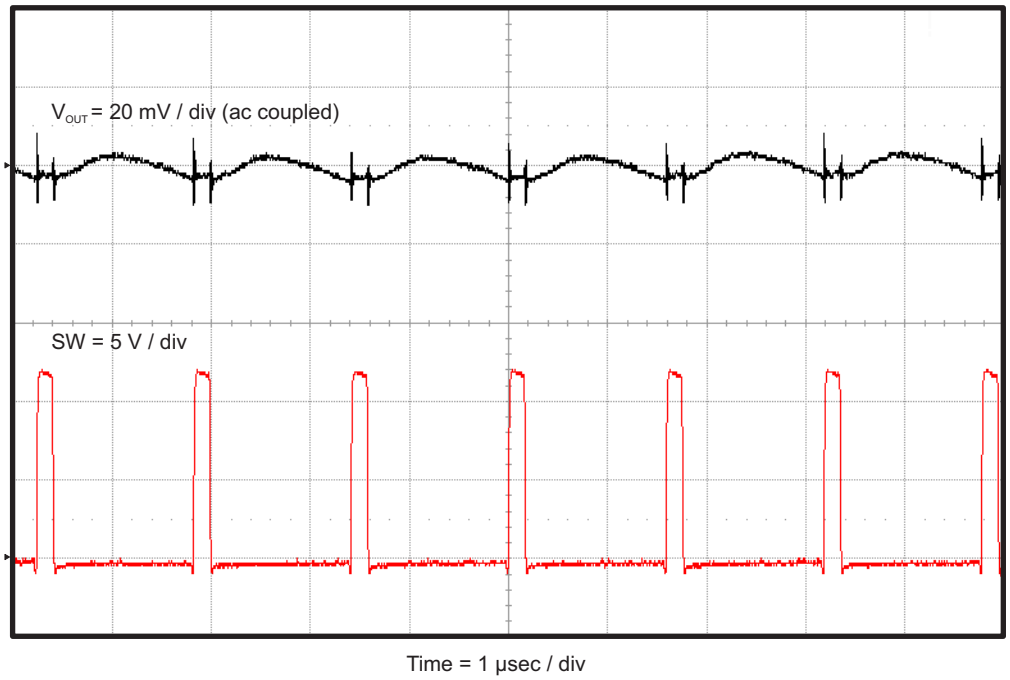

Figure 6. TPS562200EVM-601 Output Voltage Ripple, I_{OUT} = 2 A

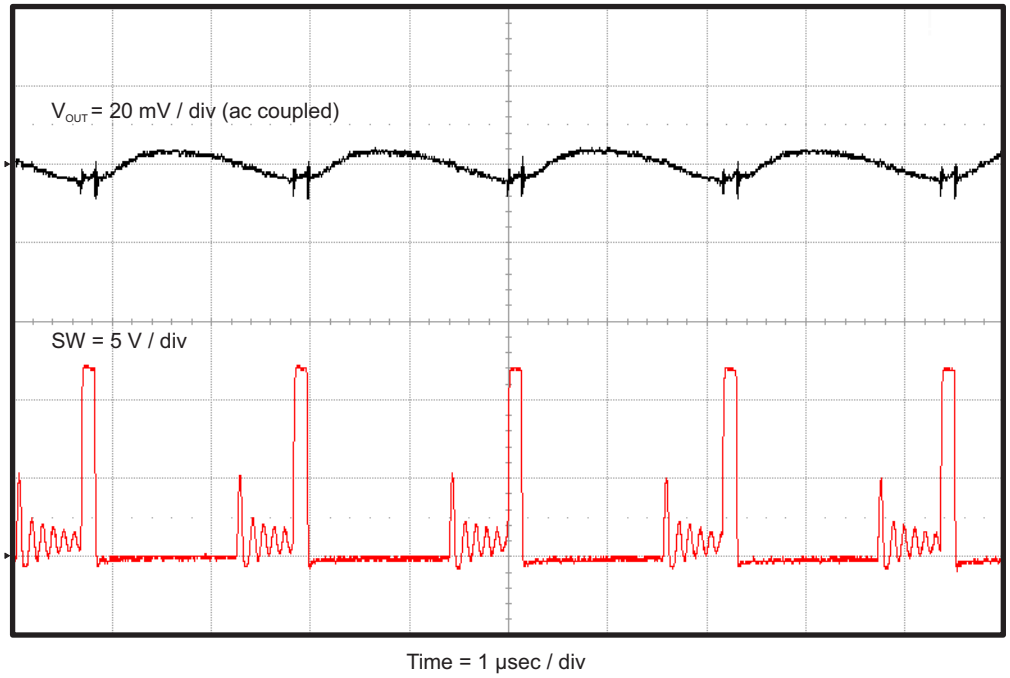

Figure 7. TPS562200EVM-601 Output Voltage Ripple, I_{OUT} = 250 mA

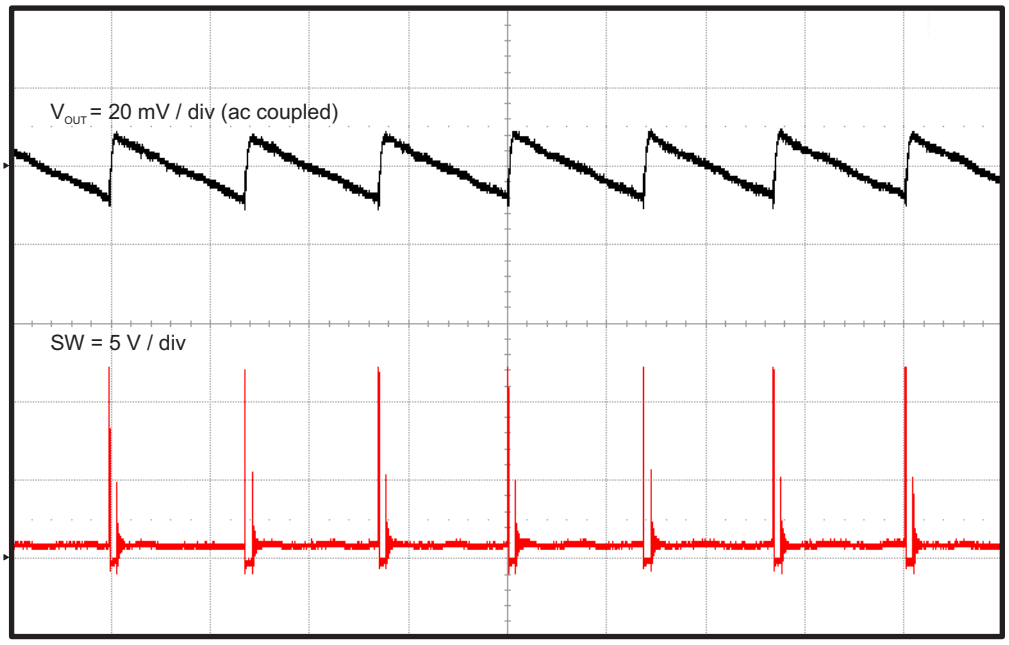

Figure 8. TPS562200EVM-601 Output Voltage Ripple, I_{OUT} = 10 mA

4.8 Input Voltage Ripple

The TPS562200EVM-601 input voltage ripple is shown in Figure 9. The output current is as indicated.

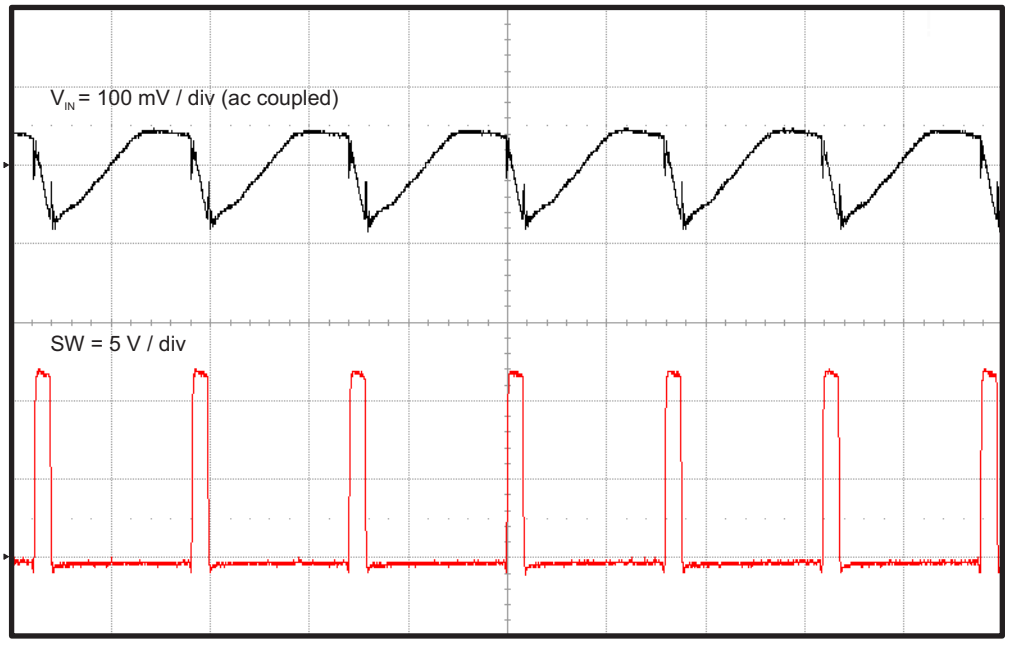

Figure 9. TPS562200EVM-601 Input Voltage Ripple, I_{OUT} = 2 A

4.9 Start-Up

The TPS562200EVM-601 start-up waveform relative to V_{IN} is shown in Figure 10. Load = 1 Ω resistive.

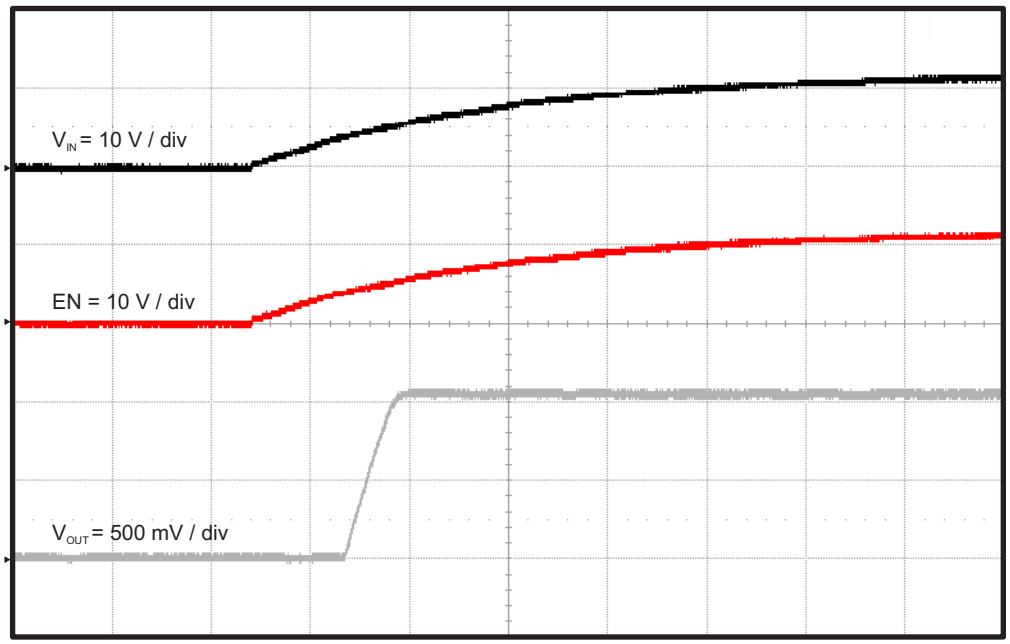

Figure 10. TPS562200EVM-601 Start-Up Relative to V_{IN}

The TPS562200EVM-601 start-up waveform relative to enable (EN) is shown in Figure 11. Load = 1 Ω resistive.

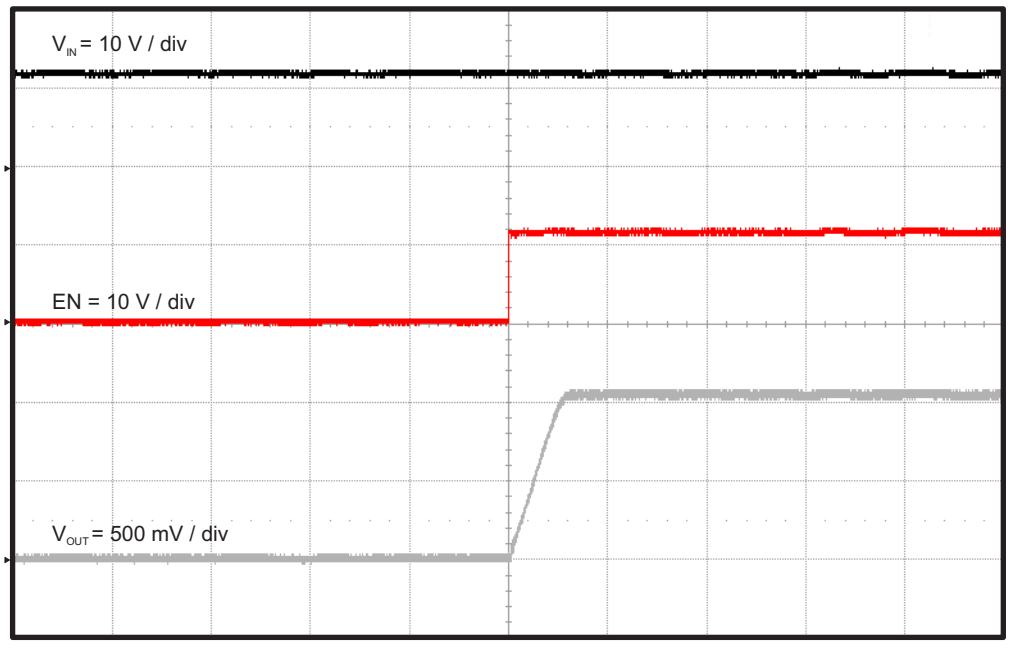

Figure 11. TPS562200EVM-601 Start-Up Relative to EN

4.10 Shut-Down

The TPS562200EVM-601 shut-down waveform relative to V_{IN} is shown in Figure 12. Load = 1 Ω resistive.

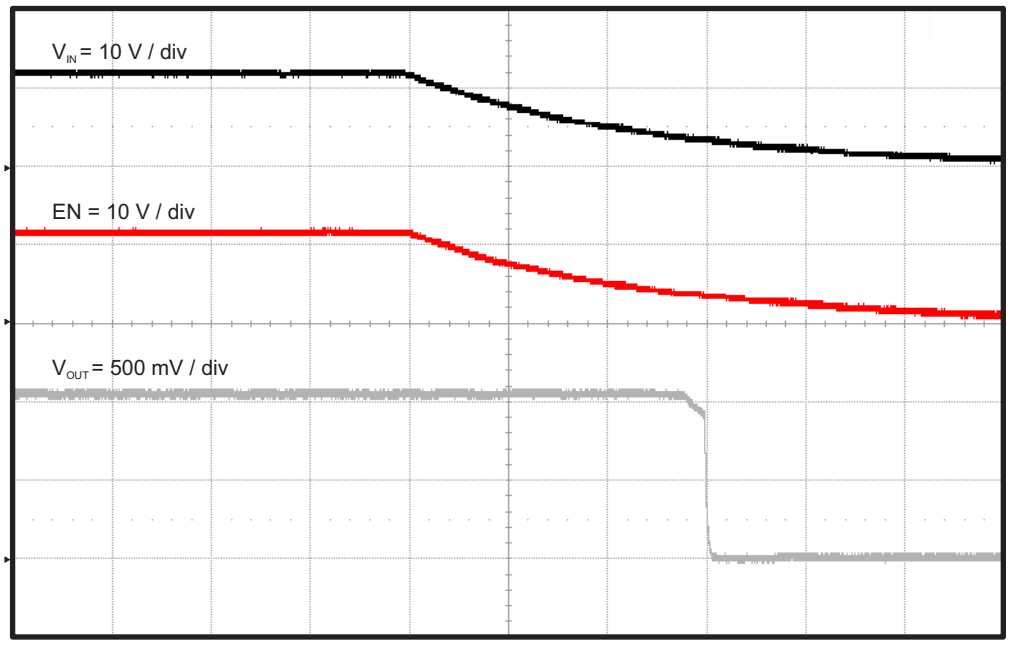

Figure 12. TPS562200EVM-601 Shut-Down Relative to V_{IN}

The TPS562200EVM-601 shut-down waveform relative to EN is shown in Figure 13. Load = 1 Ω resistive.

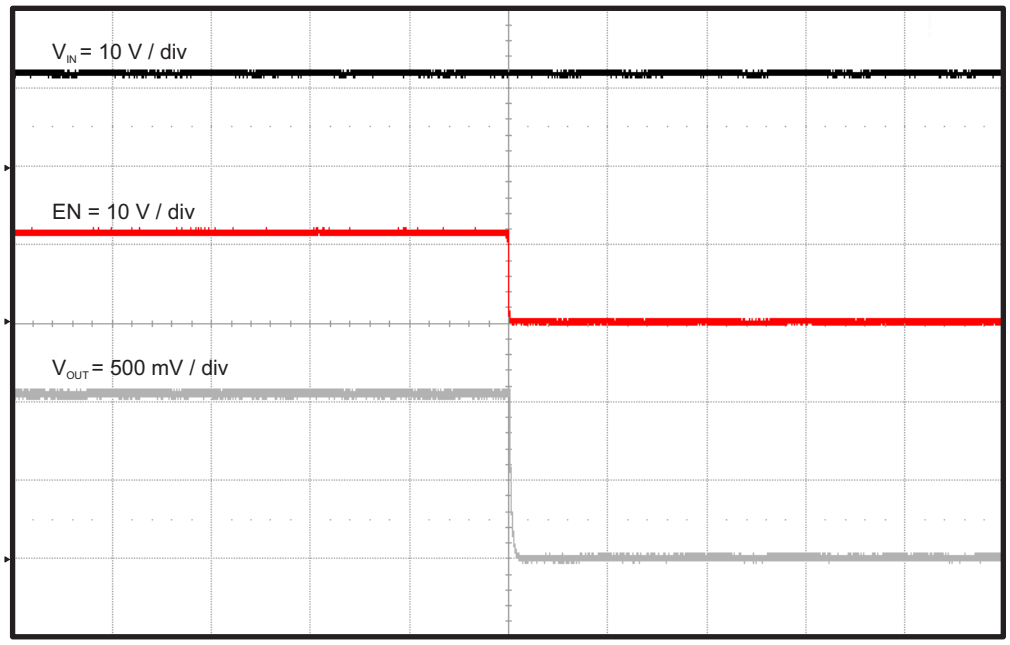

Figure 13. TPS562200EVM-601 Shut-Down Relative to EN

5 Board Layout

This section provides a description of the TPS562200EVM-601, board layout, and layer illustrations.

5.1 Layout

The board layout for the TPS562200EVM-601 is shown in Figure 14 and Figure 15. The top layer contains the main power traces for VIN, VOUT, and ground. Also on the top layer are connections for the pins of the TPS562209 and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors, C1, C2, and C3 are located as close to the IC as possible. The input and output connectors, test points, and all of the components are located on the top side. The bottom layer is a ground plane along with the switching node copper fill, signal ground copper fill and the feed back trace from the point of regulation to the top of the resistor divider network.

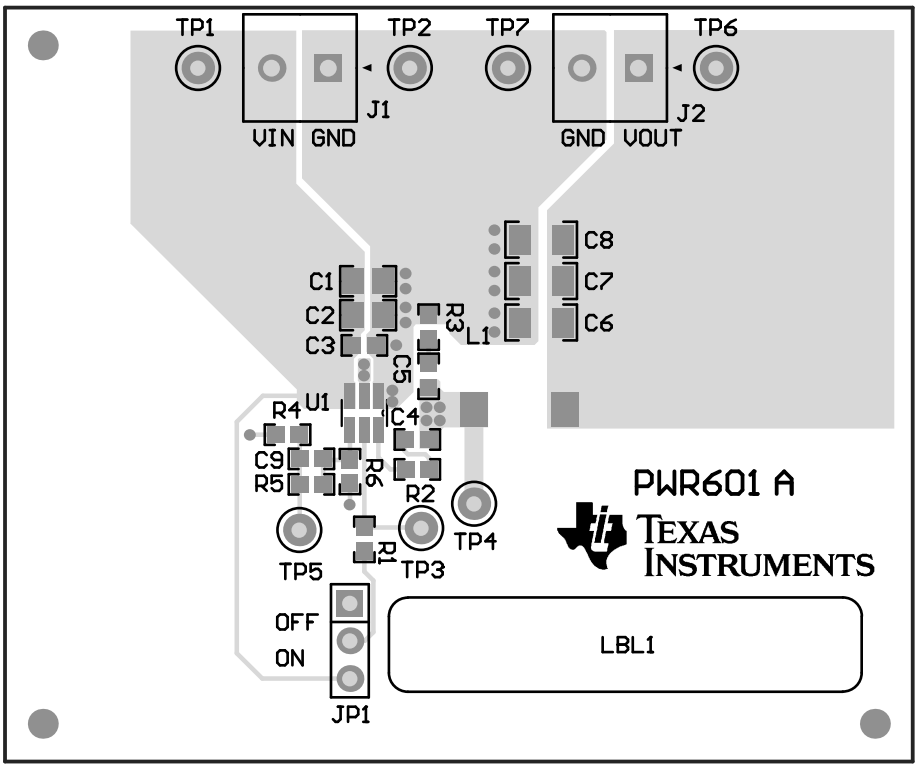

Figure 14. Top Assembly

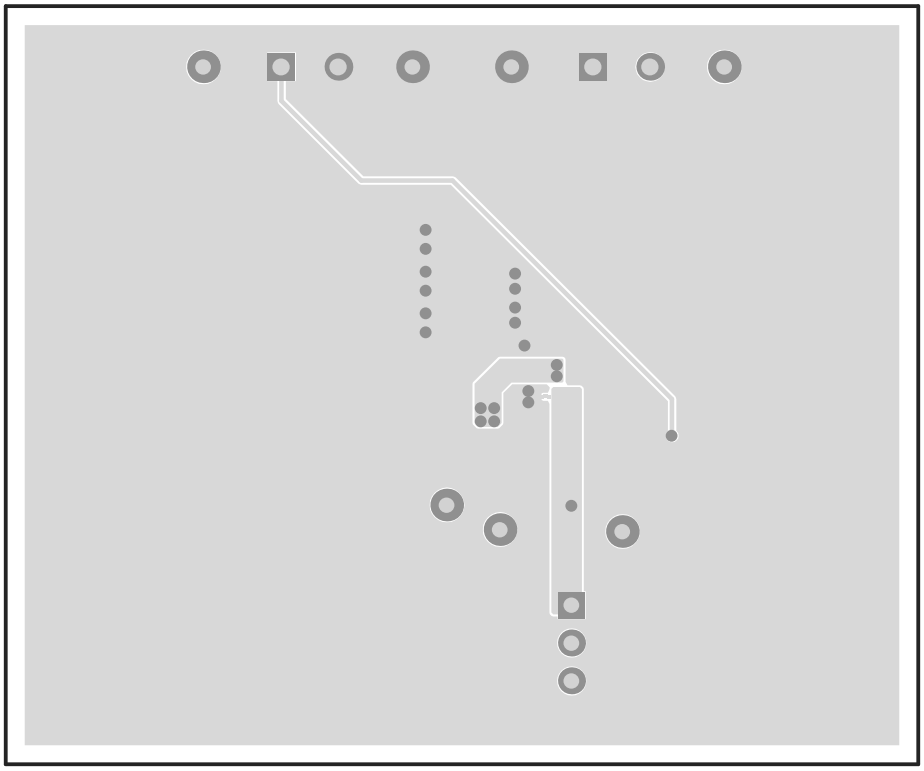

Figure 15. Bottom Layer

6 Schematic, Bill of Materials, and Reference

6.1 Schematic

Figure 16 is the schematic for the TPS562200EVM-601.

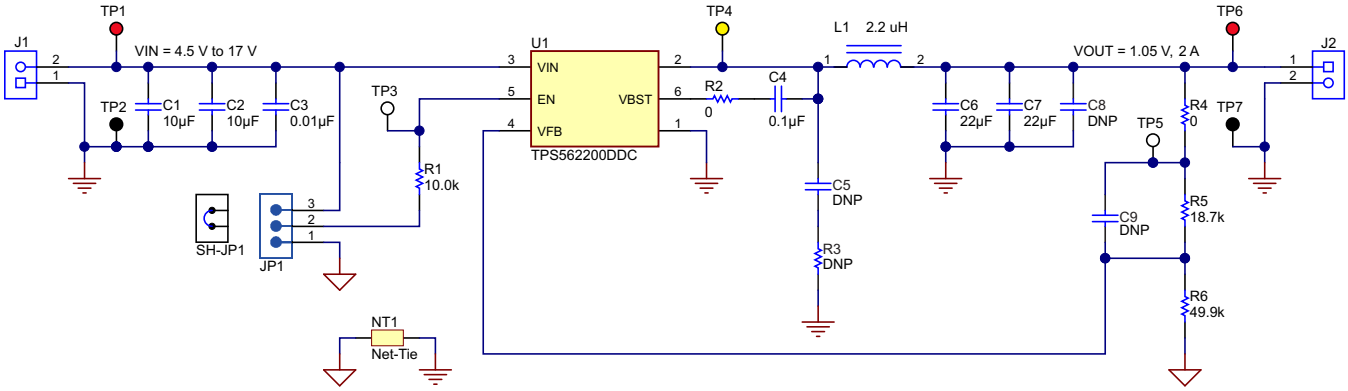

Figure 16. TPS562200EVM-601Schematic Diagram

6.2 Bill of Materials

Table 5. Bill of Materials

QTY	Value	Description	Package Reference	Part Number	Manufacturer
1		Printed Circuit Board		PWR601	Any
2	10uF	CAP, CERM, 10uF, 25V, +/-10%, X5R, 0805	0805	C2012X5R1E106K125AB	TDK
1	0.01uF	CAP, CERM, 0.01uF, 50V, +/-10%, X7R, 0603	0603	C1608X7R1H103K	TDK
1	0.1uF	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	0603	C1608X7R1H104K	TDK
2	22uF	CAP, CERM, 22uF, 6.3V, +/-20%, X5R, 1206	1206	C3216X5R0J226K	TDK
2	2x1	Conn Term Block, 2POS, 3.81mm, TH	2POS Terminal Block	1727010	Phoenix Contact
1	1x3	Header, TH, 100mil, 1x3, Gold plated, 230 mil above insulator	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
1	2.2 uH	Inductor, Power Line, Magnetic Shielded, ±30%	6.9x7.2 mm	CLF7045T2R2N	TDK
1		Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	PCB Label 1.25"H x 0.250"W	THT-13-457-10	Brady
1	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
2	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	ERJ-3GEY0R00V	Panasonic
1	18.7k	RES, 18.7k ohm, 1%, 0.1W, 0603	0603	CRCW060318K7FKEA	Vishay-Dale
1	49.9k	RES, 49.9k ohm, 1%, 0.1W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
1	1x2	Shunt, 2mm, Gold plated, Black	2mm Shunt, Closed Top	2SN-BK-G	Samtec
2	Red	Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
2	Black	Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
2	White	Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
1	Yellow	Test Point, Miniature, Yellow, TH	Yellow Miniature Testpoint	5004	Keystone
1		4.5V to 17 V Input, 2-A Synchronous Step-Down SWIFT Converter with Eco-Mode, DDC0006A	DDC0006A	TPS562200DDC	Texas Instruments
0		CAP, CERM, 0603	0603		
0		CAP, CERM, 1206	1206		
0		CAP, CERM, 0603	0603		
0		RES, 0603	0603		

6.3 Reference

1. *TPS56220x 4.5 V to 17 V Input, 2-A Synchronous Step-Down Voltage Regulator in SOT-23* data sheet (SLVSCB0)

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

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For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

【Important Notice for Users of EVMs for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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EVALUATION BOARD/KIT/MODULE (EVM)
WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM’s electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI’s recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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